**3GPP TSG RAN WG1 Meeting #114 R1-230xxxx**

**Toulouse, France, August 21st – 25th, 2023**

**Agenda item: 9.17**

**Source: Nokia, Nokia Shanghai Bell**

**Title: Summary of email discussion on NR\_MIMO enhancements on CSI**

**Document for: Discussion and Decision**

# 1 Introduction

This thread will discuss the draft CR to 38.214 for NR MIMO CSI.

First checkpoint for this discussion: **September 5, 6:00am UTC!**

# 2 Discussion – first round

The comments in this section are based on version 0 of the the draft CR available in the **Post RAN1#114 discussion.**

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| Company | Comments | Editor reply/Notes |
| CATT | **Comment 1(TypeII Doppler):**For the following new added text, it’s better to clarify the value of$ K\_{p}$.

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| For a *CSI-ReportConfig* configured with *codebookType* set to 'typeII-Doppler-r18' or 'typeII-Doppler-PortSelection-r18', the UE reports a CSI report only if receiving at least one aperiodic or $K\_{p}$ periodic or semipersistent consecutive CSI-RS transmission occasions for each CSI-RS resource in the corresponding CSI-RS Resource Set for channel measurement and/or one CSI-IM occasion for interference measurement no later than the CSI reference resource and within the same DRX Active Time, when DRX is configured, and drops the report otherwise. The value of $K\_{p}\in \{1,2,4\}$ is indicated by UE capability. |

**Comment 2(CJT):**There is no agreement to restrict the value of restrictedCMR-Selection when NTRP=1, so we suggest to add related text according to the following agreement.**Agreement**For the Rel-18 Type-II codebook refinement for CJT mTRP, support ……* if NTRP =1, that the NTRP-bit bitmap (for dynamic TRP selection) is not reported

**Proposed change:**

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| The UE may be configured with higher layer parameter *restrictedCMR-Selection*. If *restrictedCMR-Selection* is configured, the number of selected CSI-RS resources is $N=N\_{TRP}$. Otherwise, the UE is expected to select $N$ CSI-RS resources, with $1\leq N\leq N\_{TRP}$, and the selection is reported with an $N\_{TRP}$-bit bitmap, $b\_{N\_{TRP}}, …,b\_{1}$, where the CSI-RS resources are mapped from bit $b\_{1}$ to bit $b\_{N\_{TRP}}$ by their ordering in the resource set and the first of the $N$ selected CSI-RS resources corresponds to the nonzero bit with lowest index. If NTRP=1, the $N\_{TRP}$-bit bitmap is not reported. |

**Comment 3(TypeII Doppler):**According to the following agreement, only *N4*=1 is supported for the refinement of the Rel-17 FeType-II port seletion codebook. Therefore, relevant text of the Rel-17 FeType-II port seletion codebook with *N4*>1 should be removed.

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| AgreementThe Rel-18 Type-II codebook refinement for high/medium velocities comprises refinement of the following codebooks:* Refinement of the Rel-16 eType-II regular codebook, with N4>=1
* Refinement of the Rel-17 FeType-II port selection (PS) codebook, based on the common design with the Refinement of the Rel-16 eType-II regular codebook, except for the supported set of parameter combinations, with N4=1
	+ Time-/Doppler-domain reciprocity is not assumed
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**Proposed change:**

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| - For Enhanced Type II for predicted PMI with $N\_{4}>1$ (see Clause 5.2.2.2.10), Part 1 contains RI (if reported), the CQI (if the higher layer parameter *TDCQI* is set to '1-1' or '1-2') or the first CQI (if the higher layer parameter *TDCQI* is set to '2') and the total number of reported non-zero amplitude coefficients across layers. The fields of Part 1 – RI (if reported), CQI, and the total number of reported non-zero amplitude coefficients across layers – are separately encoded. Part 2 contains the second CQI (if the higher layer parameter *TDCQI* is set to '2') and the PMI of the Enhanced Type II for predicted PMI ~~or Further Enhanced Type II Port Selection for predicted PMI~~. Part 1 and 2 are separately encoded. |

**Comment 4(TypeII Doppler):**According to the following agreement, the support of *l = (n – nCSI,ref )* is UE optional. Therefore, the relevant description should be added to 5.2.1.4.2 in 38.214.

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| **Agreement**On the CSI reporting and measurement for the Rel-18 Type-II codebook refinement for high/medium velocities, when UE-side prediction is assumed, support UE “predicting” channel/CSI after slot *l* where the location of slot *l* is configured (from multiple candidate values) by gNB via higher-layer signalling* Candidates of slot *l* location include the legacy CSI reference resource location (*n* – *nCSI,ref* ) and slot (*n*+*δ*) where *δ* ≥ 0
* FFS: Possible value(s) of *δ* and possible value(s) of WCSI

Note: Per legacy behavior, the legacy CSI reference resource, i.e., (*n* – *nCSI,ref* ), is reused for locating the last CSI-RS occasion used for a CSI reportFor a UE that supports UE-side prediction, the support of *l* = (*n* – *nCSI,ref* ) is UE optional |

**Proposed change:**

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| Subject to UE capability, a UE configured with a *CSI-ReportConfig* with the higher layer parameter *N4* and *reportQuantity* set to 'cri-RI-PMI-CQI' is assumed to support UE-side CSI prediction. The reported PMI indicates predicted precoder matrices associated with $N\_{4}$ consecutive slot intervals, each with duration of $d$ slots, where the value of $N\_{4}\in \{1,2,4,8\}$ is configured by *N4*. If the UE is configured with an aperiodic CSI-RS resource set for channel measurement, the value, in number of slots, of the time unit $d\in \{1,m\}$ is configured by higher layer parameter *d*, where $m$ is defined in Clause 5.2.1.4.1. If the UE is configured with a periodic or semi-persistent CSI-RS resource set for channel measurement, the value of $d$ is equal to the periodicity of the CSI-RS resource. The earliest of the $N\_{4}$ slot intervals starts at slot $l=n+δ$, where $n$ is the uplink slot in which the CSI is reported and the slot offset $δ$ is configured by higher layer parameter *delta* and $δ\in \{-n\_{CSI\\_ref},0,1,2\}$ with $n\_{CSI\\_ref}$ defined in Clause 5.2.2.5. The value $δ=-n\_{CSI\\_ref}$ can be configured subject to UE capability.- For $N\_{4}=1$, the UE is expected to report a predicted PMI for slot interval $[l,l+d-1]$, ~~where the initial slot~~ $l$ ~~is configured by the slot offset~~ $δ\in \{-n\_{CSI\\_ref},0,1,2\}$ ~~and~~ the value $δ=-n\_{CSI\\_ref}$ can be configured only for $d>1$. A UE can be configured with $N\_{4}=1$ if the higher layer parameter *codebookType* is set to 'typeII-Doppler-r18', or 'typeII-Doppler-PortSelection-r18'.- The reported CQI is associated with slot $l$ and the reported PMI.- For $N\_{4}>1$, the UE is expected to report a PMI which indicates predicted precoder matrices associated with slot intervals $[l+j⋅d, l+(j+1)⋅d-1]$, for $j=0,…,N\_{4}-1$~~, where the initial slot~~ $l$ ~~is configured by the slot offset~~ $δ\in \{-n\_{CSI\\_ref},0,1,2\}$~~, with~~ $n\_{CSI\\_ref}$ ~~defined in Clause 5.2.2.5~~. A UE can be configured with $N\_{4}>1$ if the higher layer parameter *codebookType* is set to 'typeII-Doppler-r18'. |

**Comment 5(TypeII Doppler):**For *N4*=1, both *d*=1 and *d*>1 are supported with $δ=-n\_{CSI\\_ref}$. Hence, the text of ‘the value $δ=-n\_{CSI\\_ref}$ can be configured only for $d>1$’ is not inaccurate. According to the following conclusion, if $δ=-n\_{CSI\\_ref}$ and *d*=1, there is no enhancement to UE measurement and CSI calculation. Therefore, the relevant description in 5.2.1.4.2 of 38.214 should be revised.

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| **Conclusion** On the usage of CSI reporting and measurement for the Rel-18 Type-II codebook refinement for high/medium velocities, there is no consensus in *supporting any specification enhancement* for the following assumptions:* Legacy UE procedure for CSI measurement/calculation (equivalent to the combination of *l* = (*n* – *nCSI,ref* ) and WCSI=1)
* gNB-side prediction
	+ Note: This doesn’t preclude any gNB implementation
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**Proposed change:**

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| Subject to UE capability, a UE configured with a *CSI-ReportConfig* with the higher layer parameter *N4* and *reportQuantity* set to 'cri-RI-PMI-CQI' is assumed to support UE-side CSI prediction. The reported PMI indicates predicted precoder matrices associated with $N\_{4}$ consecutive slot intervals, each with duration of $d$ slots, where the value of $N\_{4}\in \{1,2,4,8\}$ is configured by *N4*. If the UE is configured with an aperiodic CSI-RS resource set for channel measurement, the value, in number of slots, of the time unit $d\in \{1,m\}$ is configured by higher layer parameter *d*, where $m$ is defined in Clause 5.2.1.4.1. If the UE is configured with a periodic or semi-persistent CSI-RS resource set for channel measurement, the value of $d$ is equal to the periodicity of the CSI-RS resource. The earliest of the $N\_{4}$ slot intervals starts at slot $l=n+δ$, where $n$ is the uplink slot in which the CSI is reported and the slot offset $δ$ is configured by higher layer parameter *delta*.- For $N\_{4}=1$, the UE is expected to report a predicted PMI for slot interval $[l,l+d-1]$, where the initial slot $l$ is configured by the slot offset $δ\in \{-n\_{CSI\\_ref},0,1,2\}$ ~~and the value~~ $δ=-n\_{CSI\\_ref}$ ~~can be configured only for~~ $d>1$~~.~~ , except for $δ=-n\_{CSI\\_ref}$ and *d*=1, the UE is expected to report a non-predicted PMI as described in Clause 5.2.2.2.5 or Clause 5.2.2.2.6. A UE can be configured with $N\_{4}=1$ if the higher layer parameter *codebookType* is set to 'typeII-Doppler-r18', or 'typeII-Doppler-PortSelection-r18'. |

**Comment 6(TypeII Doppler):**For Rel-18 TypeII codebook, $2\leq K\leq 8$ resources in one NZP CSI-RS Resource set are supported, but can’t be configured with two Resource Groups. Therefore, the following paragraph in 5.2.1.4.1 of 38.214 is not applicable to Rel-18 TypeII codebook.**Proposed change:**

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| Except for a *CSI-ReportConfig* configured with *reportQuantity* set to 'cri-RI-PMI-CQI' and *codebookType* set to 'typeII-CJT-r18', 'typeII-CJT-PortSelection-r18', 'typeII-Doppler-r18', or 'typeII-Doppler-PortSelection-r18', An NZP CSI-RS Resource Set for channel measurement with $2\leq K\_{s}\leq 8$ resources can be configured with two Resource Groups, with $K\_{1}\geq 1$ resources in Group 1 and $K\_{2}\geq 1$ resources in Group 2, such that $K\_{1}+K\_{2}=K\_{s}$, and with $N\in \{1,2\}$ Resource Pairs. Each Resource Pair consists of one resource from Group 1 and one resource from Group 2. The same resource can be associated with two Resource Pairs in frequency range 1 but not in frequency range 2. |

**Comment 7(TypeII Doppler):**For Rel-18 CJT, the parameter *codebookType* is used to enable this feature. For Rel-18 predicting CSI, some texts in 38.214 use the parameter *codebookType* to enable this feature, and some texts use the parameter *N4* to identify this feature. We think it is better to use only one RRC parameter to identify one feature. Therefore, we suggest that the RRC parameter *codebookType* should be used to enable Rel-18 predicting CSI for all texts in 38.214.**Proposed change:**

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| 5.2.1.4.1Subject to UE capability, a UE configured with a *CSI-ReportConfig* with the higher layer parameter *~~N4~~**codebookType* set to 'typeII-Doppler-r18', or 'typeII-Doppler-PortSelection-r18' and *reportQuantity* set to 'cri-RI-PMI-CQI' is assumed to support UE-side CSI prediction. The reported PMI indicates predicted precoder matrices associated with $N\_{4}$ consecutive slot intervals, each with duration of $d$ slots, where the value of $N\_{4}\in \{1,2,4,8\}$ is configured by *N4*. If the UE is configured with an aperiodic CSI-RS resource set for channel measurement, the value, in number of slots, of the time unit $d\in \{1,m\}$ is configured by higher layer parameter *d*, where $m$ is defined in Clause 5.2.1.4.1. If the UE is configured with a periodic or semi-persistent CSI-RS resource set for channel measurement, the value of $d$ is equal to the periodicity of the CSI-RS resource. The earliest of the $N\_{4}$ slot intervals starts at slot $l=n+δ$, where $n$ is the uplink slot in which the CSI is reported and the slot offset $δ$ is configured by higher layer parameter *delta*.5.2.1.4.2Subject to UE capability, a UE configured with a *CSI-ReportConfig* with the higher layer parameter *~~N4~~* *codebookType* set to 'typeII-Doppler-r18', or 'typeII-Doppler-PortSelection-r18' and *reportQuantity* set to 'cri-RI-PMI-CQI' is assumed to support UE-side CSI prediction. The reported PMI indicates predicted precoder matrices associated with $N\_{4}$ consecutive slot intervals, each with duration of $d$ slots, where the value of $N\_{4}\in \{1,2,4,8\}$ is configured by *N4*. If the UE is configured with an aperiodic CSI-RS resource set for channel measurement, the value, in number of slots, of the time unit $d\in \{1,m\}$ is configured by higher layer parameter *d*, where $m$ is defined in Clause 5.2.1.4.1. If the UE is configured with a periodic or semi-persistent CSI-RS resource set for channel measurement, the value of $d$ is equal to the periodicity of the CSI-RS resource. The earliest of the $N\_{4}$ slot intervals starts at slot $l=n+δ$, where $n$ is the uplink slot in which the CSI is reported and the slot offset $δ$ is configured by higher layer parameter *delta*.If the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'cri-RI-PMI-CQI', ' cri-RI-i1', 'cri-RI-i1-CQI', 'cri-RI-CQI' or 'cri-RI-LI-PMI-CQI', then the UE is not expected to be configured with more than 8 CSI-RS resources in a CSI-RS resource set contained within a resource setting that is linked to the *CSI-ReportConfig*, except when the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *~~N4~~ codebookType* set to 'typeII-Doppler-r18', or 'typeII-Doppler-PortSelection-r18', *reportQuantity* set to 'cri-RI-PMI-CQI' and the corresponding CSI-RS resource set for channel measurement is aperiodic with $K=12$ resources. |

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| ZTE | **Comment#1 (TDCP)**It was agreed that the number of CSI-RS resource sets used for TDCP measurement is limited as {1, 2, 3}. Therefore, we propose the following change.**Agreement (RAN1#114)**For the Rel-18 TRS-based TDCP reporting, the supported values of KTRS (number of configured TRS resource sets) are {1,2,3} * The candidate values {2,3} are UE optional

**Proposed change (section 5.2.1.2)**

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| For periodic and semi-persistent CSI Resource Settings, when the UE is configured with *groupBasedBeamReporting-r17*, the number of CSI Resource Sets configured is S=2, otherwise the number of CSI-RS Resource Sets configured is limited to S=1, except for periodic CSI Resource Settings, when the UE is configured with TDCP reporting, for which the number of CSI-RS Resource Sets in the CSI Resource Setting for channel measurement is limited to KTRS = {1, 2, 3} and all the CSI-RS Resource Sets are configured with the higher layer parameter *trs-Info*. |

**Comment#2 (Doppler CSI)**It was agreed that the value r=legacy Z2’ for $Z\_{2}^{'}+r$. Therefore, we propose the following change in red.**Agreement (RAN1#114)**For the Rel-18 Type-II codebook refinement for high/medium velocities, regarding Z/Z’ for Capability 2, r=legacy Z2’**Proposed change (section 5.4)**

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| - $(Z\_{2}+14\left(K-1\right)m,Z\_{2}^{'})$ or $(Z\_{2}+14\left(K-1\right)m+Z\_{2}^{'},2Z\_{2}^{'})$, according to UE reported capability, with $(Z\_{2},Z\_{2}^{'})$ of table 5.4-2, if the CSI report is configured with $N\_{4}>1$, *codebookType* is set to ‘typeII-Doppler-r18’ and the corresponding *NZP-CSI-RS-ResourceSet* for channel measurement is aperiodic with $K$ CSI-RS resources, or- $(Z\_{2}+w,Z\_{2}^{'})$ or $(Z\_{2}+w+Z\_{2}^{'},2Z\_{2}^{'})$, according to UE reported capability, with $(Z\_{2},Z\_{2}^{'})$ of table 5.4-2, if the CSI report is configured with $N\_{4}>1$, *codebookType* is set to ‘typeII-Doppler-r18’ and the corresponding *NZP-CSI-RS-ResourceSet* for channel measurement is periodic or semi-persistent with a single CSI-RS resource, or |

**Comment#3 (CJT/Doppler-CSI)**In RAN1#112, it is agreed that only one NZP-IMR/ZP-IMR can be configured for both CJT/Doppler-CSI, but, for now, it seems that corresponding restriction for NZP-IMR for interference measurement for both CJT and Doppler CSI is not specified. **Conclusion**For the Rel-18 Type-II codebook refinement for CJT mTRP, regarding interference measurement, beyond that supported in legacy specification, there is no consensus on supporting any additional enhancement on IMR (including the configuration for NZP CSI-RS for interference measurement or CSI-IM in relation to the configured CMR(s)).* Note: This implies that only one NZP CSI-RS resource for interference measurement or only one CSI-IM resource can be configured irrespective of the value of NTRP

**Agreement**For the Rel-18 Type-II codebook refinement for high/medium velocities, regarding CSI calculation and measurement, * The number of CSI-RS ports is the same for all the K configured CSI-RS resources comprising the CMR and the antenna ports for the same antenna port index across the K CSI-RS resources are the same.
* All the K configured CSI-RS resources comprising the CMR share the same BW and RE locations
* For interference measurement, legacy specification is fully reused, including the configuration for NZP CSI-RS for interference measurement or CSI-IM in relation to the configured CMR, i.e. only one NZP CSI-RS resource for interference measurement or only one CSI-IM resource can be configured irrespective of the value of K

…**Proposed change (Section 5.2.1.4.1):****-------------------------**A UE configured with a CSI-ReportConfig with the higher layer parameter reportQuantity set to 'cri-RI-PMI-CQI' and codebookType set to 'typeII-CJT-r18' or 'typeII-CJT-PortSelection-r18' is expected to be configured with 1≤K≤4 CSI-RS resources in a resource set for channel measurement. If interference measurement is performed on CSI-IM, only one resource is configured in the corresponding csi-IM-ResourceSet. If interference measurement is performed on NZP CSI-RS, only one resource is configured in the corresponding *NZP-CSI-RS-ResourceSet*.A UE configured with a CSI-ReportConfig with the higher layer parameter N4 and reportQuantity set to 'cri-RI-PMI-CQI', is expected to be configured with K∈{4,8,12} aperiodic CSI-RS resources or with a single periodic or semi-persistent CSI-RS resource in the resource set for channel measurement. For an aperiodic CSI-RS resource set for channel measurement, the K CSI-RS resources are triggered by the same triggering instance and the separation between two consecutive CSI-RS resources is m∈{1,2} slots, which is configured by higher layer parameter in the NZP-CSI-RS-ResourceSet. The UE shall assume that the antenna port with the same port index of the K aperiodic CSI-RS resources is the same. If interference measurement is performed on CSI-IM, only one resource is configured in the corresponding csi-IM-ResourceSet. If interference measurement is performed on NZP CSI-RS, only one resource is configured in the corresponding *NZP-CSI-RS-ResourceSet*.------------------------- |  |
| NTT DOCOMO | **Comment#1 on IMR restriction for CJT/Doppler-CSI:** For the texts below, we have noticed this part exists for Doppler CSI only. We understand this comes from the slight difference between the corresponding agreements. [below copied from CR] After the CSI report (re)configuration, serving cell activation, BWP change, or activation of SP-CSI, the UE reports a CSI report only after receiving at least one CSI-RS transmission occasion for channel measurement and CSI-RS and/or CSI-IM occasion for interference measurement no later than CSI reference resource and drops the report otherwise.For a *CSI-ReportConfig* configured with *codebookType* set to 'typeII-CJT-r18' or 'typeII-CJT-PortSelection-r18', the UE reports a CSI report only after receiving at least one CSI-RS transmission occasion for each of the CSI-RS resources in the corresponding CSI-RS Resource Set for channel measurement no later than the CSI reference resource and within the same DRX Active Time, when DRX is configured, and drops the report otherwise.For a *CSI-ReportConfig* configured with *codebookType* set to 'typeII-Doppler-r18' or 'typeII-Doppler-PortSelection-r18', the UE reports a CSI report only if receiving at least one aperiodic or $K\_{p}$ periodic or semipersistent consecutive CSI-RS transmission occasions for each CSI-RS resource in the corresponding CSI-RS Resource Set for channel measurement and/or one CSI-IM occasion for interference measurement no later than the CSI reference resource and within the same DRX Active Time, when DRX is configured, and drops the report otherwise.[Copy end] Meanwhile, in our understanding, RAN1 does not intend to make any difference on interference measurement behavior between CJT and Doppler in the spec. If this is the case, it might be better to have aligned texts in between in our view. To do so, there may be two alternatives:* Alt-1: Add “and/or one CSI-IM occasion for interference measurement” to CJT part
* Alt-2: Remove ““and/or one CSI-IM occasion for interference measurement” to Doppler part
	+ This may still work in our view, when the spec is read together with the legacy text before the added parts

Alt-1 may look like the following: Based on above, we propose the following: For a *CSI-ReportConfig* configured with *codebookType* set to 'typeII-CJT-r18' or 'typeII-CJT-PortSelection-r18', the UE reports a CSI report only after receiving at least one CSI-RS transmission occasion for each of the CSI-RS resources in the corresponding CSI-RS Resource Set for channel measurement and/or one CSI-IM occasion for interference measurement no later than the CSI reference resource and within the same DRX Active Time, when DRX is configured, and drops the report otherwise.For a *CSI-ReportConfig* configured with *codebookType* set to 'typeII-Doppler-r18' or 'typeII-Doppler-PortSelection-r18', the UE reports a CSI report only if receiving at least one aperiodic or $K\_{p}$ periodic or semipersistent consecutive CSI-RS transmission occasions for each CSI-RS resource in the corresponding CSI-RS Resource Set for channel measurement and/or one CSI-IM occasion for interference measurement no later than the CSI reference resource and within the same DRX Active Time, when DRX is configured, and drops the report otherwise.We’d just like to know Editor’s view on whether any of the alternatives above require additional agreement or not. If yes, we would be happy to consider submitting TP in the next RAN1 meeting. |  |
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